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Human Adaptation in Socio-Hydrological Cycle: A Review in Geographical Perspective

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ABSTRACT
This article discusses the new socio-hydrological cycle in geography perspective and issues arising from human intervention in the hydrological cycle. Hydrology is considered as a field of water sciences, whether natural or disturbed by the use of various environmental science techniques. However, its emphasis on the impact of human 'adaptation' and its co-evolution to the hydrological cycle are sometimes left unexplored. This article traces the development of multi-dimensional and interdisciplinary 'hydrological geography' that ultimately involves the human component as an endogenous factor that alters its natural cycle. Subsequently, its discuss and analysis of importance of the new socio-hydrological perspective to geography, especially in Malaysian context.

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INTRODUCTION

The hydrological cycle is a natural water cycle that describes the process of physical change and movement of water encompassing the biosphere, lithosphere, hydrosphere and atmosphere. This water cycle is an important life support system, not only to flora and fauna, but also important to the survival of the human (Milly, 1994). Inland sources of clean water supply as well as precipitation processes are both part of the cycle. Starting with the solar energy that warming the mass of water, the process begins as evaporation, transmitted by plants to the formation of clouds that bring precipitation to land as well as the ocean. Precipitation input is an important aspect of the human ecosystem (Thomas and Soroosh, 2002). The presence of water has led to the growth of traditional economic activities such as farming and agriculture. The precipitation that eventually created a continuous irrigation system and deepened the social and hydrological relationship. The relationship between the social and hydrological elements ultimately became so harmonious and has sparked the early human civilization of the world.

Teachers in schools have taught geographical knowledges for students to understand the complexity of water cycle. However, discussions of geophysical elements in particular at atmospheric and water phase changes have dominated the process. Although there is a presence of human factors that influence the process of the cycle, it is seen as an 'external factor' which can quickly be addressed by adding an element of 'adaptation' to the hydrological system (Sivapalan et al., 2012). Water cycle analysis and processes are seen as one-way, i.e. the changes in the geophysical environment of the people around it and the anthropogenic adaptation of the hydrosphere subsystem.

Many researchers in water sciences have stated their views on the 'inefficiencies' of this one-way system (Baldassarre et al. 2009; Berry et al., 2005; Gordon et al., 2008). Their view, dominated the geophysical influence of the water cycle process (Kandasamy et al., 2014). Today, the changing aspects of the hydrosphere subsystem need to be seen in the form of inter-human ecological coupling (Baldassarre et al., 2009) and in co-evolution (Berry et al., 2005), which should be the basic thinking of the geographer's today.

Human and water subsystem in hydrology

The field of research between sociology and hydrology has received little attention as it is not seen as significant in the current state of technology and the emphasis on science and engineering aspects in hydrological studies. According to modern hydrologists (Sivapalan et al., 2012), a coupled model of the interaction between water subsystems and human subsystems exists as shown in Figure 1. These interactions will generally see how water subsystems can produce 'hydrological hazards' when the geophysical conditions of the basin are affected with any shock or excess input of precipitation such as extreme weather.

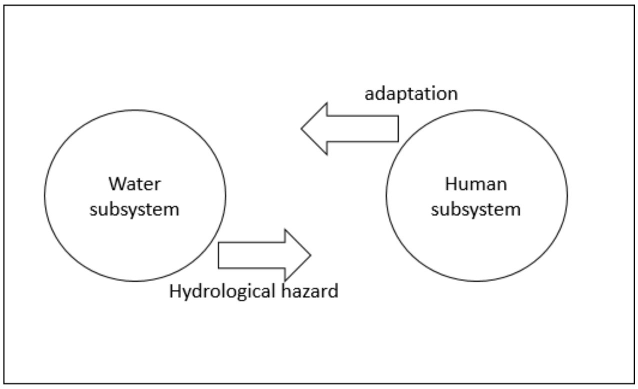

Fig1: Interaction between water and human subsystems

Hydrological hazards are capable of increasing the risk of catastrophic damage to human ecosystems that inhabit the river valleys. The presence of flood events that bring destruction and losses (tangible or intangible) will cause the community population to be exposed to increasing danger over time (Wagener et al., 2010). However, the pressure on demand for food and shelter and housing has led to an increasing flux of migration to the basin corridor. Previous studies (Green et al. 2011; Myers et al., 2008) have found that adaptation factors to hydrological hazards have made the fertile valleys still inhabited by communities that are increasingly preparing for disaster adaptation measures.

This can be seen by the development of water infrastructure such as the construction of levees, dams and even the restructuring of rivers (Schultz & Elliott 2012; Noorazuan 2003a; Noorazuan 2003b; Noorazuan et al., 2011). The infrastructure has managed to reduce the impact of disasters in the medium period of time. As a result, the community's awareness of disaster risk has gradually diminished over time. Their concerns over the risks of disasters eventually degraded, resulting in increased population and community formation in the basin corridor environment.

According to hydrologists, long-term human subsystems have the potential to negatively impact the water subsystem (Baldassarre et al. 2009). For example, the structured or altered river banks was built, not only changed the river drainage system, but also the basin hydrology cycle. The deepening of the river beds, for example, will further enhance the capacity of the river's water storage, which is the volume of water per unit of time. Although, small scale flood frequency can be mitigated by the construction of such infrastructure, larger flood events (at low frequencies) may occur in the future (Sivapalan 2011; Baldassarre et al. 2009).

Therefore, the coupling model between the water subsystem and the human subsystem is no longer in the relationship as in Figure 1 above. Human disruption to the hydrological cycle in the name of 'adaptation' has changed our perception of the role of 'adaptation' itself. This means that the coupling between the two subsystems is bilateral, reciprocal and seems to move like a pendulum swing. The human subsystem has the potential to have an impact on the water subsystem. This aspect of adaptation by both the community and the administrators has turned into a triggering factor for anthropogenic hazards and therefore could affect the equilibrium of the water subsystem.

The Murrumbidgee River Basin

The discussion on the dynamics of the new socio-hydrological relationship may be easily understood by examining the Murrumbidgee River Basin, which is certainly not in Malaysia. This case will prove a failure between the water and human subsystems in the hydrological cycle. The Murrumbidgee River Basin is part of the Murray-Darling Basin, Australia.

The Murrumbidgee River Basin is a drainage basin that has served the agricultural community for the past 100 years. According to Sivapalan et al (2012), the basin has become a fertile agricultural site that produces food products such as cereals and other important fruits in the Murray-Darling Basin. According to Kandasamy et al. (2014), the development phase of the Murrumbidgee River basin can be divided into four phases or major periods.

Kandasamy et al (2014) described the four phases as follows;

Era 1: 1900–1980 - development of irrigation infrastructure and related to raw water control

Era 2: 1960–1990 - a gradual increase in environmental quality degradation

Era 3: 1990–2007 - awareness of environmental impact and sustainable / sustainable management strategies

Age 4: 2007 to date - failures in environmental planning models and government intervention

The Murrumbidgee River Basin, which has a population of about 540,000 experiencing a positive agricultural development in general. During the first phase or period (1990-1980) the area accounted for 25 per cent of fruit and vegetable production for the New South Wales region and almost half of the country's rice production came from the basin (ABS, 2013).

The second era (1960–1990) suffering the decrease in environmental quality, especially water quality. During that period, widespread saltwater infiltration caused disruption to agricultural water supply and threatened the wastewater ecosystem in the area (GWG, 1996; MDBC, 1999). According to ABS (2013), the total annual loss of the agricultural sector is AUD 230 million and AUD40 million is the cost of environmental loss. Water pollution is not only a pollution issue in the basin, but the presence of blue algae also has a negative impact on agriculture and the basin ecosystem. Sewage from sewage treatment plants and agricultural waste such as insecticides are also the cause of the algae bloom phenomenon.

The third era (1990–2007) saw agricultural growth and the population of the basin declining. The employment of the agricultural sector seems to have ceased during that period and the contribution of the agricultural sector to GDP has declined dramatically since 1950. During the same period, the quality of the environment has deteriorated. Despite the implementation of several more sustainable environmental management strategies, the stream environment of the river ecosystem has reached a critical stage (Kandasamy et al., 2014). The government has developed a program known as the Water Reform Package while approving a new water law enactment (ABS, 2013).

However, the last era (2007 to date) has seen how the integrated aspects of water resource management (IWRM) have failed to achieve its objectives. Therefore, the government's drastic step in purchasing water rights from the community (though opposed by the peasant community) had to be done to preserve the quality of the aquatic environment and wastewater in the basin. It has disrupted agricultural operations and has been detrimental to the local farmers community. The action by the government to provide the space and opportunity to save the quality of the environment is seen to be well-suited with the co-evolutionary truth and coupling of the relationship between the human subsystem and the water subsystem in the hydrological cycle. The move is not seen as an external factor alone, but rather as a reciprocal effect - in response to the human subsystem in the efforts to save the health of the basin ecosystem. According to Sivapalan et al. (2012) in the context of the Murrumbidgee River basin, the response and feedback from human subsystems to water subsystems have had a positive impact on the environment. He points out that the aspects of 'water reallocation to nature' and 'room for a river' form the core of the new 'socio-hydrological' dynamics - a result of the coupling between human subsystems and water subsystems in the hydrological cycle.

Other studies have shown that co-evolution of the sociohydrological coupling system ends with the aspects of 'water reallocation to nature' and 'room for a river', and even arguably with more interesting items such as environmental customer' (Liu et al., 2013; Baldassarre et al., 2013; Heine and Pinter, 2012; Remo et al., 2012).

Conclusion

Would it be possible if the socio-hydrological effects of Murrumbidgee occurred in our homeland? The authors feel that it is not uncommon to have such a phenomenon as the 'levee effect' in the Klang Valley, the adaptation effect in Sg Lembing or the impact of the development of debris on the biodiversity of the coastal zone in Terengganu. Only God can determine the right time and space for this to happen in Malaysia.

Of course, the analysis of this socio-hydrological effects is still vague and lacking of coverage. The author pray that strategic management aspects of the hydrology issue in Malaysia be able to incorporate elements such as 'water reallocation to nature' and 'room for a river', even 'environmental customer' in future planning plans.

Since the beginning of human civilization, the interaction between water resources and human life has been very close and harmonious. Today, nearly one billion people are living in the flood plains. Geography in the East or West has emphasized aspects of the natural water cycle that begin with precipitation inputs and end with major outputs such as river discharge and drainage. Due to location factors close to the water source, the need for transportation systems and its fertile land, river ecosystems have become central to human economic activity. However, human settlements in these flood plains are often threatened by waterborne disasters.

Adaptation measures to control the flood disaster are now to be viewed in a deeper perspective, which is a 'reciprocal effect' - in response to the human subsystem in efforts to save the health of the basin ecosystem. It is time for geographers to make such an interplay between water-human subsystems of producing reciprocal effects of both positive and negative sides. The Murrumbidgee basin naturally make physical geographical displacements more interesting to study and practice because it involve factors such as adaptation effects and levee effects that greatly help us understand new sociological views for maintaining the health of the river basin ecosystem. The authors hope that this paper provides a new strategy such as 'water reallocation to nature' and 'room for a river' can be the core of the new 'socio-hydrological' dynamics - a result of the coupling of human-water subsystems in the cycle hydrology.

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